Technical Memo

ANL/EES-TM-324

AIR POLLUTION LEVELS AND REGULATIONS IN THE UNITED KINGDOM

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ARGONNE NATIONAL LABORATORY

Energy and Environmental Systems Division

Operated by

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under Contract W-31-109-Eng-38

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Printed in the United States of America. Available from National Technical Information Service, U. S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161.

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue, Argonne, Illinois 60439

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by

Marshall Monarch

Energy and Environmental Systems Division
Environmental and Resource Assessment Group

July 1986

work sponsored by

U.S. DEPARTMENT OF ENERGY
Assistant Secretary for Fossil Energy
Office of Planning and Environment

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FOREWORD

This report is one of a series of three prepared for the Office of Fossil Energy (OFE) of the U.S. Department of Energy. Each report deals with one country in which acid deposition, commonly referred to as acid rain, has been a prominent issue of public discussion. The three countries covered in this series of reports are Canada, the Federal Republic of Germany, and the United Kingdom. For each country, air pollution control regulations and trends in air quality and emissions are broadly outlined, then are compared with corresponding regulations and trends in the United States. Since acid rain is the intended field of application, the reports generally deal only with sulfur dioxide, nitrogen oxides, ozone, and total suspended particulates. Carbon monoxide has not been covered, as it is not emitted in significant quantities by the stationary combustors of fossil fuels of interest to OFE. The primary purpose of these reports is to supply reasonable comparisons and information to OFE personnel involved in policy development and speech preparation.

AIR POLLUTION LEVELS AND REGULATIONS IN THE UNITED KINGDOM

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1 AIR POLLUTION LEGISLATION AND REGULATIONS

This section discusses the principal legislation governing the regulation of air pollution in the United Kingdom. As in the United States, air pollution is regulated at the central, regional (equivalent to the U.S. state level), and local or city levels. At the central government level, enforcement is the responsibility of the Health and Safety Executive, through the Industrial Air Pollution Inspectorate and, for pollution from motor vehicles, the Department of Transport. Regional air pollution responsibilities are handled by such bodies as the Greater London Council (GLC), whose jurisdiction for air pollution control covers the city of London and 32 surrounding boroughs. At the local level, these boroughs and the city also have certain responsibilities for air pollution control.

1.1 NATIONAL LEGISLATION

The principal central government statutes that govern air pollution at all levels of government (i.e., central, regional, and local) in the United Kingdom are as follows:[1]

- *Control of Pollution Act of 1974*: enables the central government to regulate the sulfur and lead content of liquid fuel used for combustion in furnaces or engines.

- *Health and Safety at Work, etc., Act of 1974*: enables the central government to regulate emissions of noxious or offensive substances from specified plants or equipment by requiring use of the "best practicable means" for preventing emissions.

- *Road Traffic Acts of 1972 and 1974*: enable the central government to set emission limits for vehicles. Limits set under these acts cover smoke from vehicles with compression ignition (diesel) engines and carbon monoxide, nitrogen oxides (NO_x), and hydrocarbons from vehicles with positive ignition (petrol) engines. All heavy-goods vehicles exceeding 1.5 metric tons in weight must also be annually tested under this legislation.

- *Clean Air Acts of 1956 and 1968*: allow the London borough councils to prohibit the emission of smoke from dwellings and other buildings in their districts, and require the councils to grant to householders 70% of the reasonable cost of installing suitable domestic smokeless appliances. The borough councils may also control the height of new chimneys serving furnaces greater than a certain size to prevent emissions from becoming prejudicial to health or a nuisance.

- *Public Health Acts of 1936 and 1961*: address noxious or offensive emissions (other than smoke, grit, and dust) from premises not specifically dealt with under other legislation. Responsibility for enforcement rests with the London borough councils.

- *Public Health (Recurring Nuisances) Act of 1969*: addresses nuisances, which include "any dust or effluvia caused by any trade, business, manufacture, or process and being prejudicial to the health of or a nuisance to the inhabitants of the district." Responsibility for enforcement rests with the London borough councils.

- *Alkali, etc., Works Regulation Act of 1906*: allows specialist control of certain complex industrial processes registerable under the act. The act has been partly superseded by the Health and Safety at Work Act of 1974 and the Control of Pollution Act of 1974. Enforcement is the responsibility of the Industrial Air Pollution Inspectorate, which operates on a regional basis.

1.2 AMBIENT AIR QUALITY STANDARDS

The United Kingdom has no national ambient air quality standards or guidelines. However, the GLC has developed some air quality guidelines for London and the surrounding boroughs. These guidelines are summarized in Table 1.1 and are compared with the ambient air quality standards established by the U.S. Environmental Protection Agency (EPA) for sulfur dioxide (SO_2), total suspended particulates (TSP), and ozone. The GLC has no guidelines for NO_x. As Table 1.1 indicates, the GLC guidelines are more stringent than the EPA standards -- but are merely guidelines, since no legislation exists enabling the Secretary of State for the Environment to promulgate national air quality standards.[2] Moreover, the Industrial Air Pollution Inspectorate and local authorities are not required to take into account ambient air quality standards when setting emission standards for individual sources of pollution.

1.3 EMISSION STANDARDS AND REGULATIONS

The Industrial Air Pollution Inspectorate does not have the authority to require plants to limit air pollution emissions to a prescribed rate, although water authorities may do so for water pollutant discharges. Specific emission limits exist only for particulate matter (PM). For all other pollutants, the Inspectorate must control source emissions on a case-by-case basis using the concept of "best practicable means." This concept has never been precisely defined in legal terms but, based on commentary by the

TABLE 1.1 GLC and EPA Ambient Air Quality Standards for SO_2, TSP, and Ozone ($\mu g/m^3$)

Agency	SO_2, Annual Mean	TSP, Annual Mean	Ozone, Daily 1-h Maximum
GLC	60[b]	40[c]	160
EPA	80[d]	75[e], 60[f]	235

[a]Arithmetic mean unless otherwise specified.

[b]With 98% of measurements < 200 $\mu g/m^3$.

[c]With 98% of measurements < 120 $\mu g/m^3$.

[d]With 1 day permitted to exceed 365 $\mu g/m^3$.

[e]Annual geometric mean, with 1 day permitted to exceed 260 $\mu g/m^3$.

[f]Secondary welfare standard, with 1 day permitted to exceed 150 $\mu g/m^3$.

Source: Ref. 1 for GLC data; 40 CFR 50, as amended, 50 FR 37501 (Sept. 13, 1985) for EPA data.

Chief Alkali Inspector, appears to be based "on the principle of reasonable judgment of the state of the environment into which an effluent is being emitted, the nature of the relevant abatement technology, and the economic circumstances of the polluter."[3]

The United Kingdom has no specific national emission limits for SO_2. The concept of "best practical means" is applied on a case-by-case basis. However, national limitations exist on the amount of sulfur allowed in liquid fuels (i.e., fuels with a specific gravity greater than that of gas oil). These limitations are listed in Table 1.2. Most are not based on air pollution control requirements but on technical requirements for transport, storage, and combustion equipment. Only diesel and gas oil are subject to national sulfur limitations for the purpose of reducing SO_2 emissions. At the local level, the city of London has imposed a limit of 1% sulfur on heavy liquid fuels in order to reduce SO_2 emissions. This limit was imposed on all combustion sources that commenced operation in 1972 or later; existing sources are allowed to burn higher-sulfur fuel oil until 1987.

Table 1.3 contains the U.K. PM emission limits for fossil fuel combustion units with a rated capacity of greater than 1.25 x 10^6 Btu/h. The U.K. limits are expressed in terms of heat input (mg/thermies [th]) or concentration (mg/m^3) and have been converted in the table to a lb/10^6 Btu heat input basis for ease of comparison with EPA New Source Performance Standards (NSPS).

The U.S. emission limits for power plant combustion units become more stringent for units placed into service after 1958. A sliding emission limitation scale is applied to nonelectric utility combustion units with a maximum limitation of 0.45 lb/10^6 Btu. Pre-1958 utility combustion units must meet this emission limit regardless of capacity, and units in service after 1958 must reduce PM emissions by over 75%.

As the table suggests, the U.K. PM limits are considerably less stringent than the NSPS for both utility and nonutility combustion units. The U.K. level of allowable PM emissions for utility units is more than three times the level allowed by NSPS.

TABLE 1.2 U.K. Limits on the Sulfur Content of Liquid Fuels

Liquid Fuel	Sulfur Limit (wt %)
Diesel oil	0.3[a]
Gas oil	0.5[a]
Fuel oil	
Light	3.5[b]
Intermediate	4.0[b]
Heavy	4.5[b]
Extra heavy	5.0[b]
London fuel oil[c]	1.0

[a]National limitations for SO_2 control.

[b]Maximum permitted by general fuel specifications (i.e., unrelated to air pollution control). In practice, the sulfur content of fuel oils is about 3%.

[c]Limit applies in London only to all fuel oils used in new plants after 1971 and in existing plants after 1987.

TABLE 1.3 U.K. PM Emission Limits for Fossil Fuel Combustion

Fuel Type	Plant Capacity th/h[a]	Plant Capacity 10^6 Btu/h	Type of Plant	U.K. Emission Limits[b] mg/th	mg/m^3	lb/10^6 Btu	% of NSPS Emission Limit[c]
Solid or liquid	>315	>1.25	All[d]	800-2,000	-	0.45-1.11[e]	450-1110[f]
Solid	>315	>1.25	Power plants[g] (pre-1958)	-	460	0.45	-
Solid or liquid	>315	>1.25	Power plants (1958-present)	-	115	0.11	367[h]
				-	115	0.10	333[h]

[a]A thermie (th) is equal to 3.967×10^3 Btu.

[b]The U.K. emission limits that are expressed as an exhaust gas concentration (mg/m^3) at 1 bar pressure, 15°C, and 12% CO_2 have been converted to an approximate fuel input basis (lb/10^6 Btu) using the following conversion factors: 15,645 $ft^3/10^6$ Btu (420 m^3/GJ) for solid fuel, and 13,783 $ft^3/10^6$ Btu (370 m^3/GJ) for liquid fuel.

[c]This comparison is based on emission limits only, not on the additional NSPS requirements for percentage control of potential uncontrolled emissions.

[d]Excludes pre-1958 boilers in power stations specified in footnote g and boilers in all power plants from 1958 on.

[e]A sliding scale is applied, depending on plant type and size.

[f]Comparison is with NSPS fossil-fuel-fired steam generators >250 x 10^6 Btu/h for which construction commenced after Aug. 17, 1971, with a PM limit of 0.1 lb/10^6 Btu.

[g]Applicable to power stations with boilers having an aggregate maximum continuous steam rating of at least 450,000 lb/h.

[h]Comparison is with NSPS electric utility steam generators >250 x 10^6 Btu/h for which construction commenced after Sept. 18, 1978. The NSPS PM limit for solid and liquid fuels is 0.03 lb/10^6 Btu, with reductions of potential uncontrolled emissions set at 99% for solid fuel and 70% for liquid fuel.

Source: Ref. 4 for U.K. limits.

2 ACID DEPOSITION ISSUE

2.1 EXTENT OF PUBLIC CONCERN

Acid deposition has been of concern in the United Kingdom for a number of years. "Acid fogs" were reported in London as long ago as 1934, and the concentrations of sulfuric acid measured in the air at the time caused concern.[5] During a London smog episode in 1962, unusually high levels of sulfuric acid were measured and 700 premature deaths were attributed to that episode[6] although the specific causative role of airborne acid droplets was not firmly established.[7] The acidity of the acid droplets during the smog episode was calculated to be well over 1000 times that of natural rainwater.[8]

Current concern with acid deposition is reflected by the results of a recent opinion poll conducted by the GLC. The poll showed that "people in London and Britain understand the threat that 'acid rain' poses and support action to reduce the problem."[8] Concern has also been prompted by European concern about transboundary air pollution and acid rain. The United Kingdom is a member of the European Economic Community (EEC), which has established air quality guidelines for its member countries, although the United Kingdom has not as yet followed suit. The European community has also brought pressure on the United Kingdom, through action taken by the United Nations Economic Commission for Europe (UN/ECE), to deal with the transboundary aspects of acid deposition. A convention sponsored by the UN/ECE in Geneva in 1979 resolved to "endeavor to limit as far as possible and gradually reduce air pollution, including long-range transboundary air pollution."[2] The convention established an executive body that meets once a year. These annual meetings provide an occasion for policy to be discussed and for pressure to be applied by those countries wanting significant reductions in emissions. In June 1984, ministers and other officials from 32 countries met in Munich to discuss ways of fighting air pollution. A number of countries pledged to cut their SO_2 emissions by 30% by 1993. The emission reduction is to be based on either the member countries' total 1980 SO_2 emissions or the estimated SO_2 emissions transported across their frontiers. In July 1985 in Helsinki, 18 European countries and Canada signed a protocol committing them to reducing their SO_2 emissions. The signatory nations are sometimes referred to as the "30% club." The United Kingdom did not sign the protocol. Most Eastern European countries pledged only to reduce the amount of SO_2 that they transport across their frontiers.

The U.K. government has indicated an intent to reduce national SO_2 emissions by 30% from 1980 levels by the end of the 1990s.[9] However, the government has stated that it "is not prepared to commit this country to expensive methods of abating sulfur dioxide emissions when the benefits are so uncertain."[10] Some expect continuing international pressure on Britain to sign the protocol and "join the 30% club."[2]

2.2 ACIDITY MEASUREMENTS AND TRENDS

The U.K. Review Group on Acid Rain[11] has reported that, in 1984, the annual average rainfall acidity throughout the nation was from 2 to 32 times greater than natural acidity levels, which are between 2.5 and 10 microequivalents per liter (i.e., between 5.6 and 5.0, respectively, on the pH scale). This finding is illustrated on the acidity scale in Fig. 2.1. The review group evaluated the average acidity of precipitation throughout the United Kingdom based on data collected in 1978-1980 and determined that the eastern and southeastern areas of the nation received the highest annual average concentration of acid in precipitation over that 3-yr period (see Fig. 2.2a). However, in terms of acid deposition, the pattern is different, as indicated in Fig. 2.2b. The high concentration of deposited acid in Fig. 2.2b correlates well with areas receiving the highest amount in annual rainfall. Based on these data, it appears that acid deposition is sensitive to the volume of acidic rainfall as well as to the concentration of acid in the rainfall (i.e., acidity).

The Scientific Services Branch of the GLC has concluded that there is a lack of good-quality data to show how the acidity of precipitation has changed in the United Kingdom over the last few decades.[8] Some limited data exist from Pitlochry, Scotland, where the acidity of precipitation has been monitored since 1974.[12] As Fig. 2.3 indicates, the acidity of precipitation has decreased at Pitlochry since 1979. The 1983 level is approximately 66% of the average for the period 1974-1983.

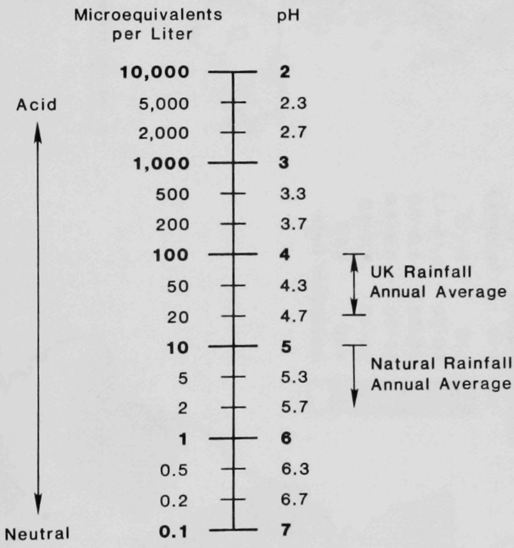

FIGURE 2.1 Natural and U.K. Rainfall Acidity

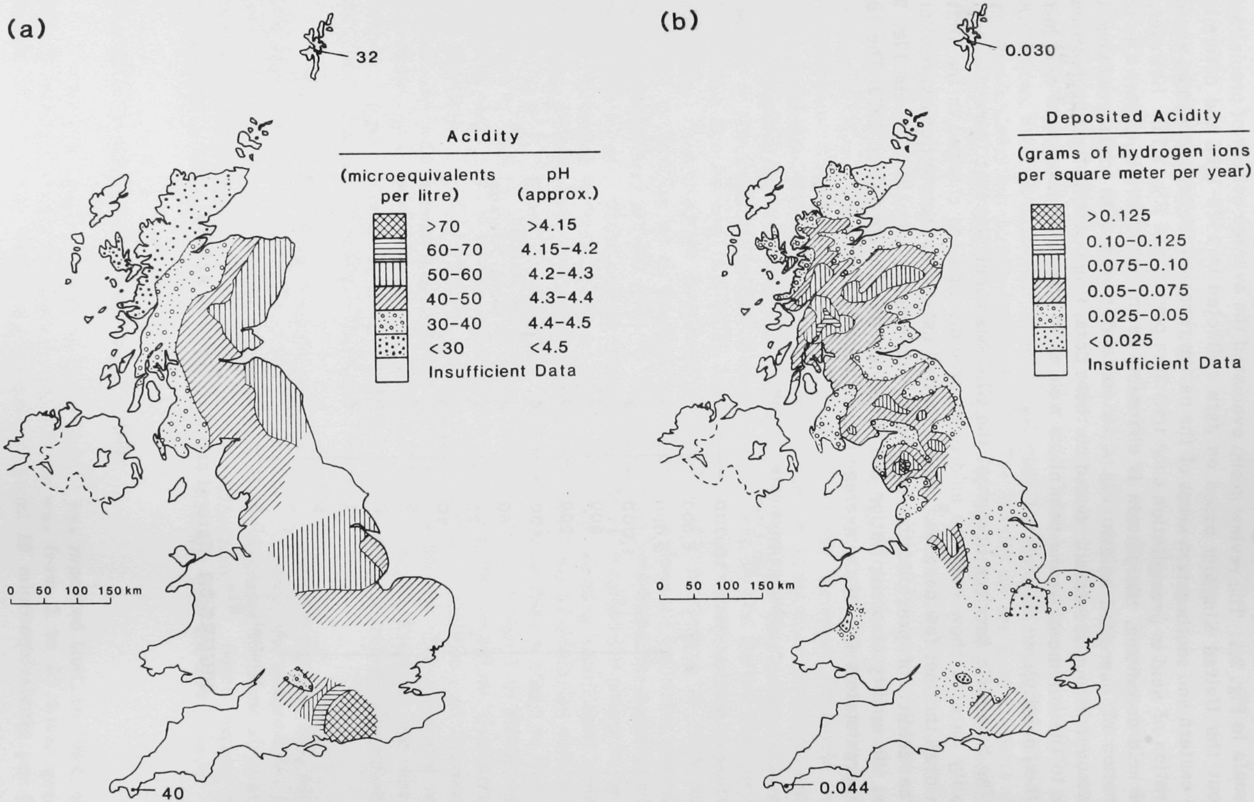

FIGURE 2.2 U.K. Average Precipitation Acidity and Deposited Acidity, 1978-1980

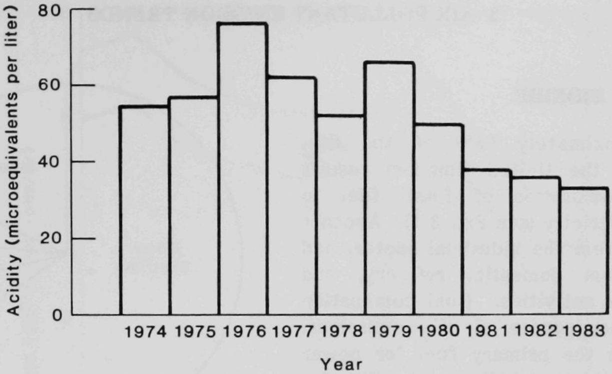

FIGURE 2.3 Acidity of Precipitation at Pitlochry, Scotland, 1974–1983

3 AIR POLLUTANT EMISSION TRENDS

3.1 SULFUR DIOXIDE

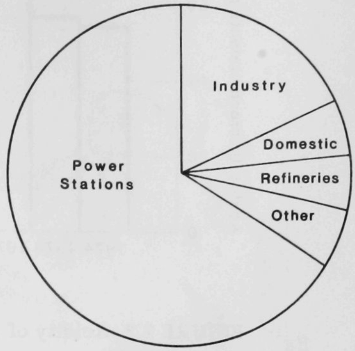

FIGURE 3.1 U.K. Emissions of SO_2 by Sector, 1982 (Source: Ref. 13)

Approximately 65% of the SO_2 emissions in the United Kingdom results from the combustion of fossil fuel to generate electricity (see Fig. 3.1). Another 20% stems from the industrial sector, and the rest from domestic, refinery, and miscellaneous activities. Coal combustion is the primary source of SO_2 emissions, since coal is the primary fuel for power plants and industrial boilers. As Fig. 3.2 shows, between 1972 and 1982, total emissions of SO_2 decreased by approximately 30% to 4 million metric tons.[13] This reduction was primarily due to energy conservation measures and a reduction in fuel-burning activity.[8] However, emissions from coal combustion, approximately 2.7 million metric tons, remained fairly constant. The level of SO_2 emissions in 1982 was slightly less than 75% of that in 1972, primarily as a result of a reduction in high-sulfur fuel oil consumption and a slight overall reduction in fuel consumption in the commerce and industry sector.

3.2 NITROGEN OXIDES

Emissions of NO_x by source category between 1972 and 1982 are shown in Fig. 3.3. As in the case of SO_2 emissions, the major source of NO_x emissions is the combustion of fossil fuel to produce electricity. Emissions from the electric utility sector were fairly constant over the 10-yr period shown. However, emissions from the second largest source category, transportation, grew significantly, rising from approximately half the level emitted by the utility sector in 1972 to nearly the same level in 1982. Emissions from the third major source category, commerce and industry, were slightly higher than the level emitted in transportation in 1972 but decreased relative to transportation by 1982 due to a reduction in fossil fuel consumption by the commerce and industry sector. In 1982, total NO_x emissions in the United Kingdom were only slightly greater than they were in 1972, primarily due to a decrease in stationary source fossil fuel consumption, which offset the growth in vehicle fuel consumption.

3.3 COMPARISON OF U.K. AND U.S. EMISSION TRENDS

In Figs. 3.4 and 3.5, U.S. and U.K. trends in SO_2 and NO_x emissions are compared on the basis of data compiled by the Organization for Economic Cooperation and

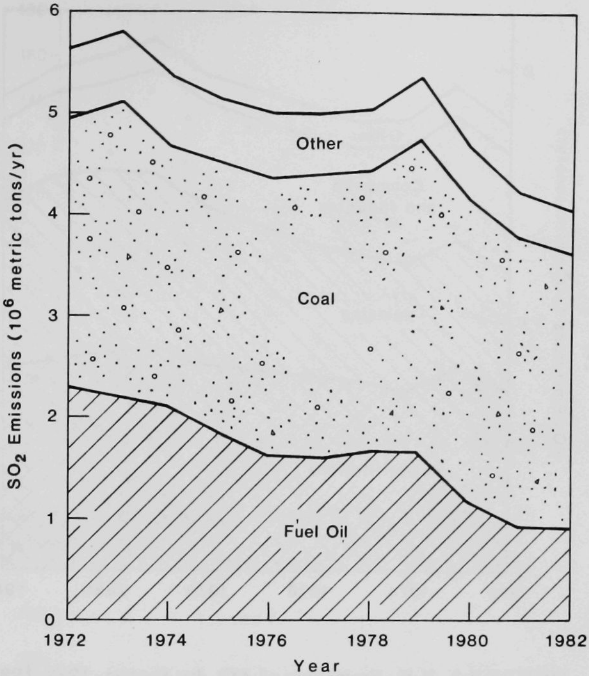

FIGURE 3.2 U.K. Emissions of SO_2 by Fuel Source, 1972–1982 (Source: Ref. 13)

Development.[14] For this comparison, the pollutant emission data in both figures have been normalized to a base of 100 in 1970.

As Fig. 3.4 indicates, SO_2 emissions decreased in both countries between 1970 and 1983. In the United States, this decrease was approximately linear from 1970 to 1979, but became more marked from 1980 to 1983. In the United Kingdom, the trend was more irregular. From 1970 to 1975, SO_2 emission levels declined consistently, but then increased between 1975 and 1979, although only by 25% of the level of emissions reduction experienced during the previous years. After 1979, SO_2 emissions declined again, in 1983 reaching only 60% of the 1970 level. Relative to 1970, the United Kingdom demonstrated a greater percentage decrease in emissions than the United States, but this greater decrease was not necessarily the result of more vigorous air pollution control; general economic conditions also influenced this trend.

The comparison of U.S. and U.K. trends in NO_x emissions (see Fig. 3.5) shows a different picture than in the case of SO_2 emissions. In the United States, NO_x emissions demonstrated a consistent upward trend until 1979, when they were approximately 15%

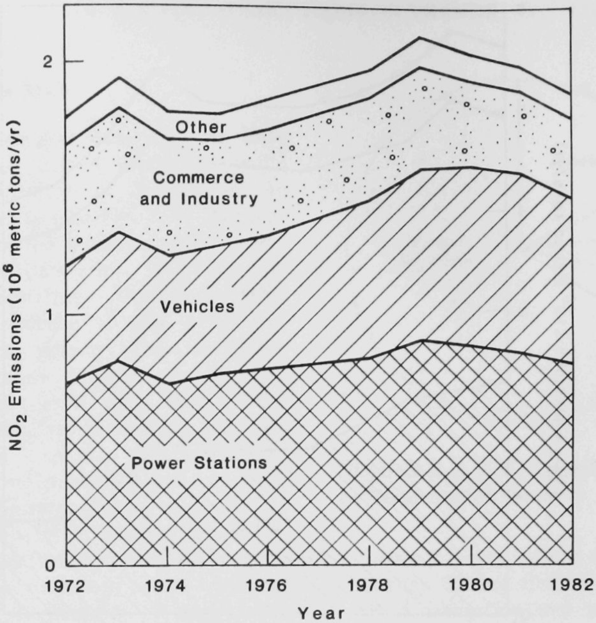

FIGURE 3.3 U.K. Emissions of NO_x by Sector, 1972-1982 (Source: Ref. 13)

higher than the level in 1970. After 1979, emissions showed a general decline and by 1983, they were only 5% above the 1970 level. In the United Kingdom, NO_x emissions declined from 1970 to 1975, when they reached approximately 85% of the 1970 level. Emissions of NO_x then increased until 1979, reaching about 95% of the 1970 level. From 1979 to 1983, the trend in NO_x emissions again reversed, with 1983 emissions at 80% of the 1970 level. Relative to 1970, NO_x emissions in the United Kingdom experienced a generally greater percentage decline than in the United States, and demonstrated greater fluctuations. As with SO_2 emissions, general economic conditions influenced this trend.

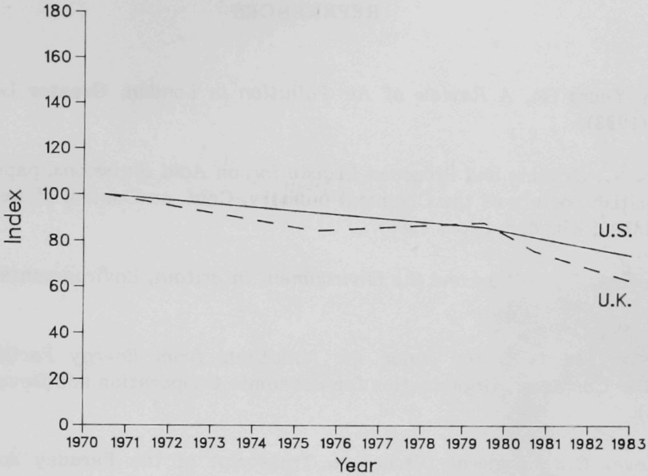

FIGURE 3.4 U.S. and U.K. Trends in SO_2 Emissions (Source: Ref. 14)

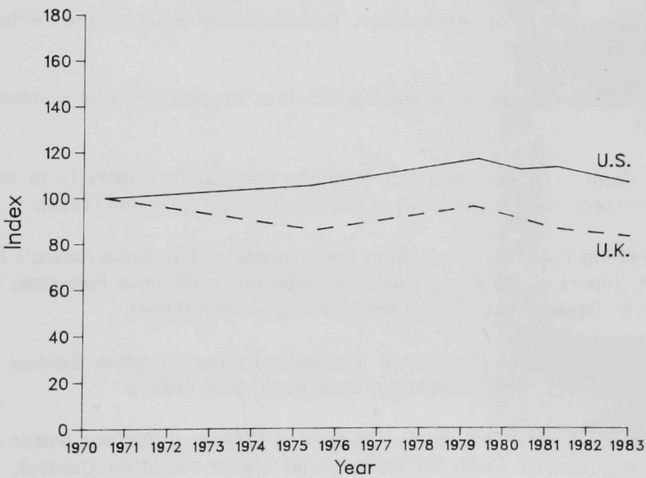

FIGURE 3.5 U.S. and U.K. Trends in NO_x Emissions (Source: Ref. 14)

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